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(54) **Wide band radiating device capable of several polarizations**

(57) The radiating device comprises, on a substrate 10, two pair 12, 12 of thin conductive sectors disposed head-to-tail on either side of an axis of symmetry, with planes of symmetry passing through this axis. The conductive sectors have substantially the same area as the insulating sectors defined between these conductive sectors. The sectors may have curved sides and the substrate need not be planar e.g. conical, pyramidal.

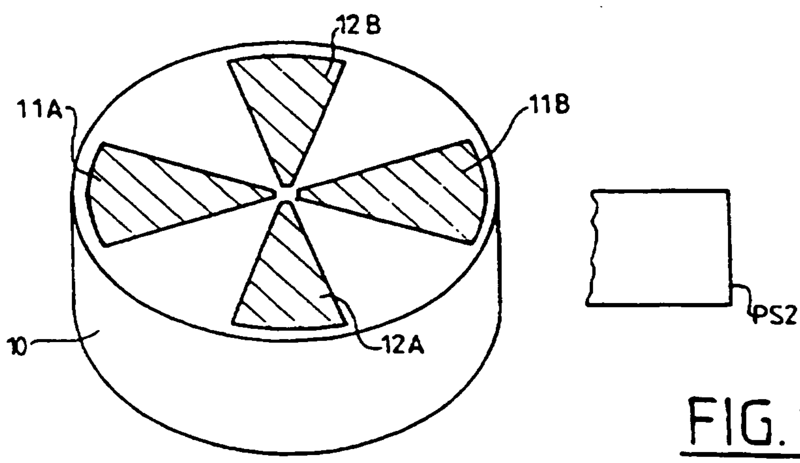

FIG. 2

GB 2 316 233 A

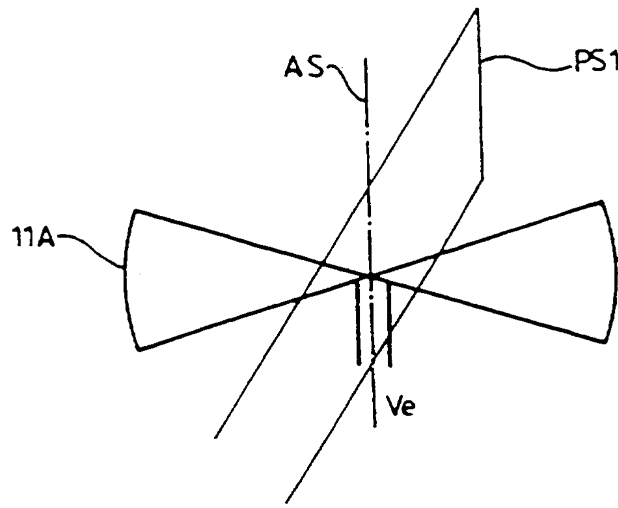

FIG. 1

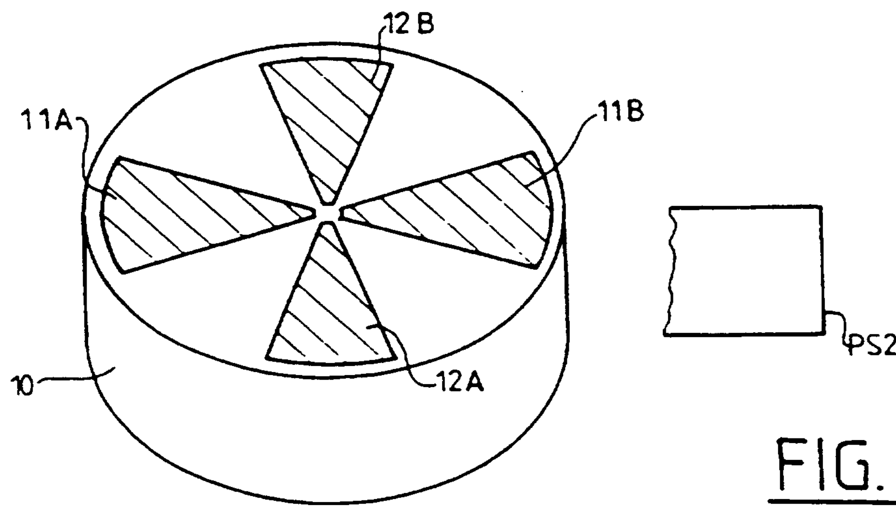

FIG. 2

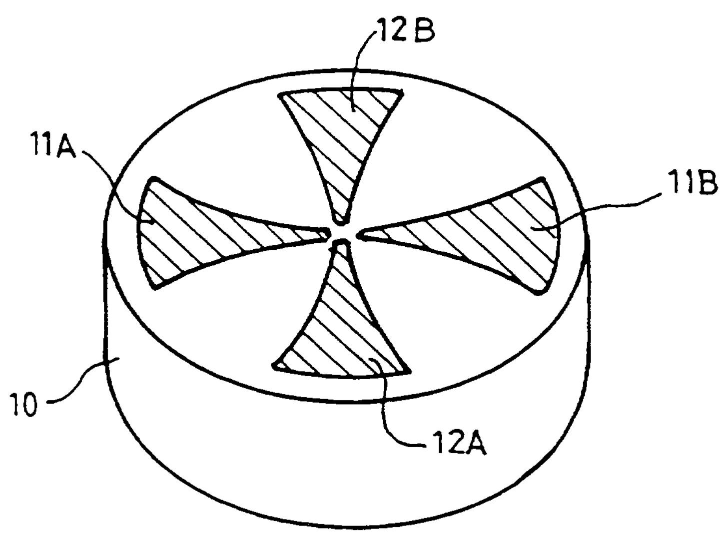

FIG. 2E

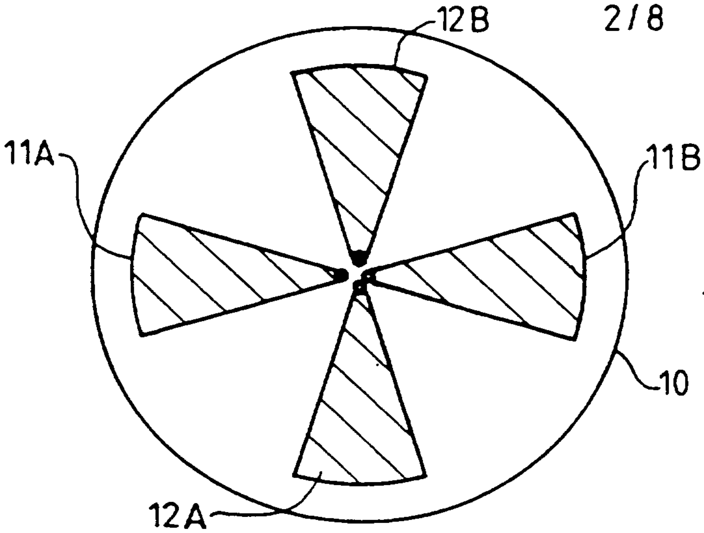

FIG. 2A

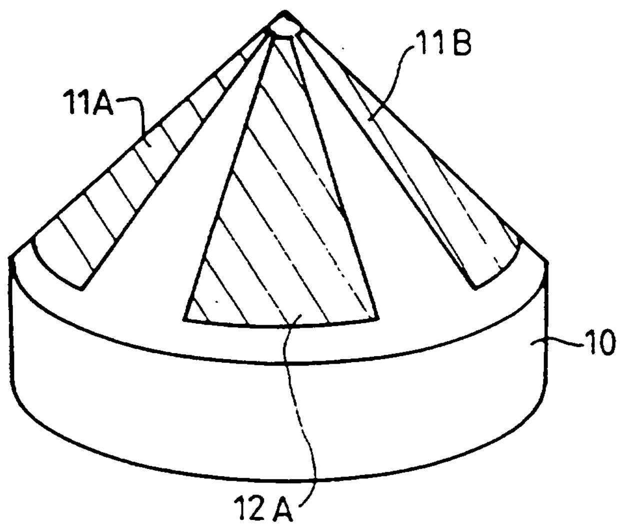

FIG.2B

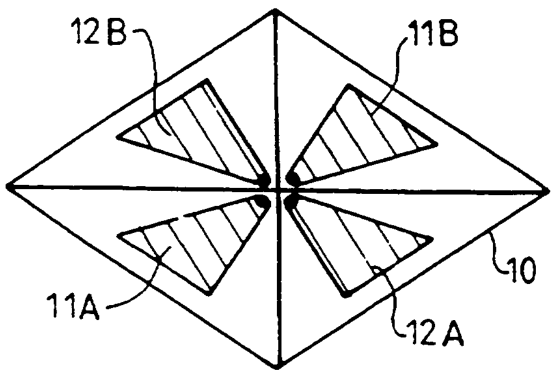

FIG. 2C

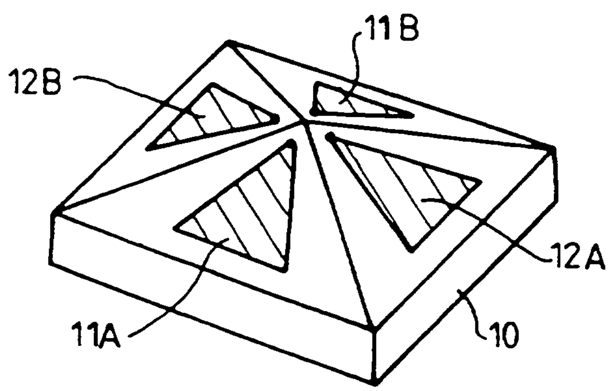

FIG.2D

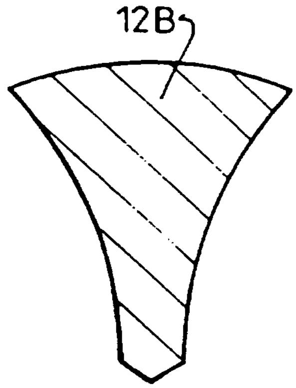

FIG. 2F

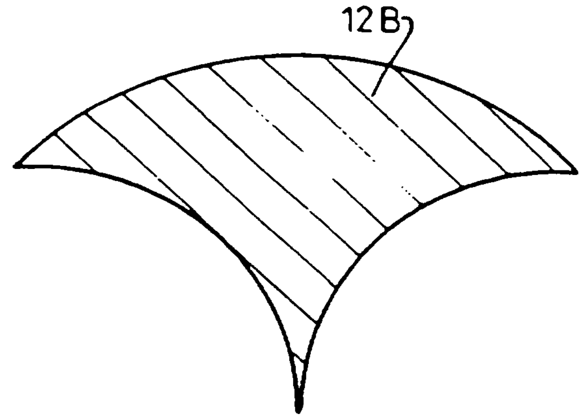

FIG. 2G

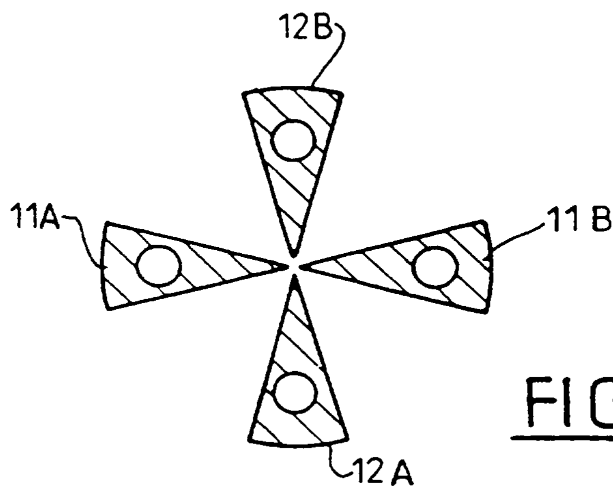

FIG. 2H

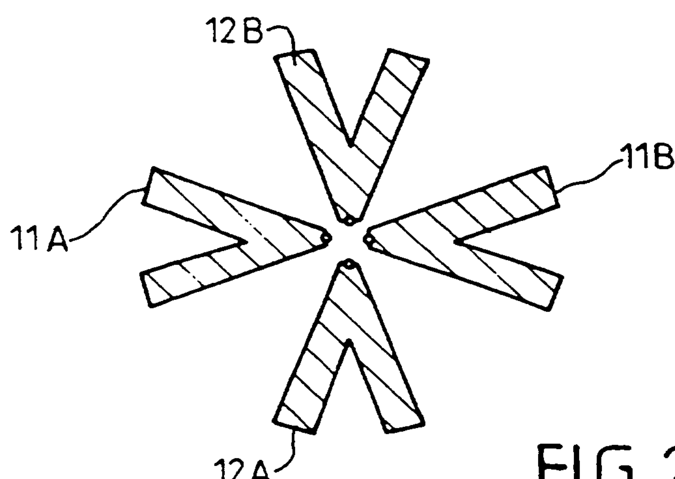

FIG. 2I

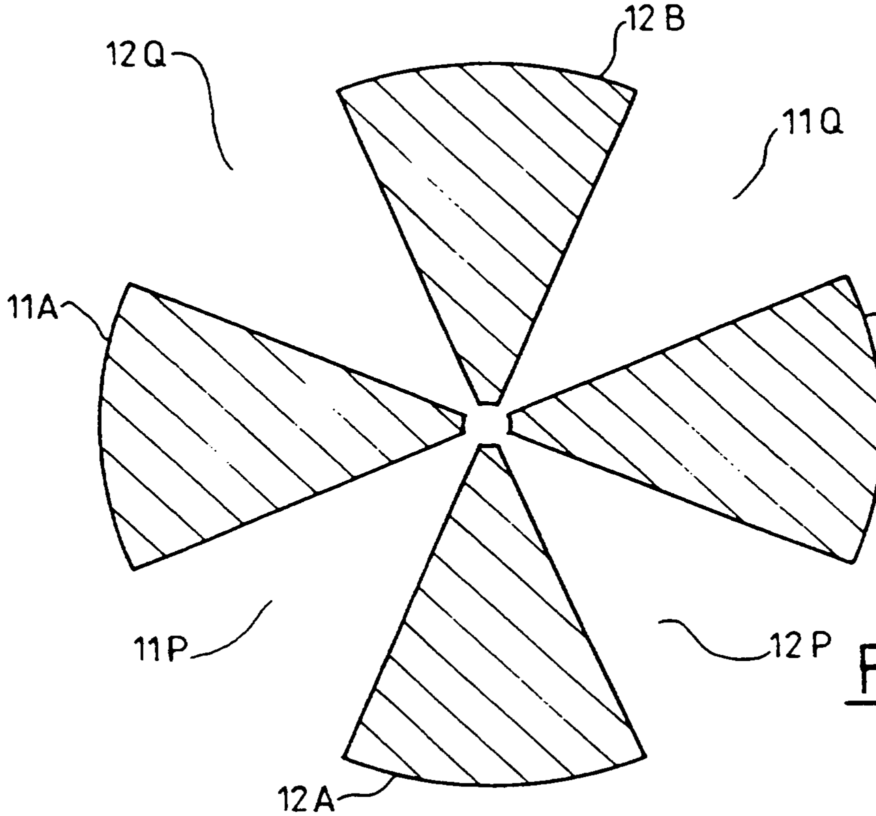

FIG. 3

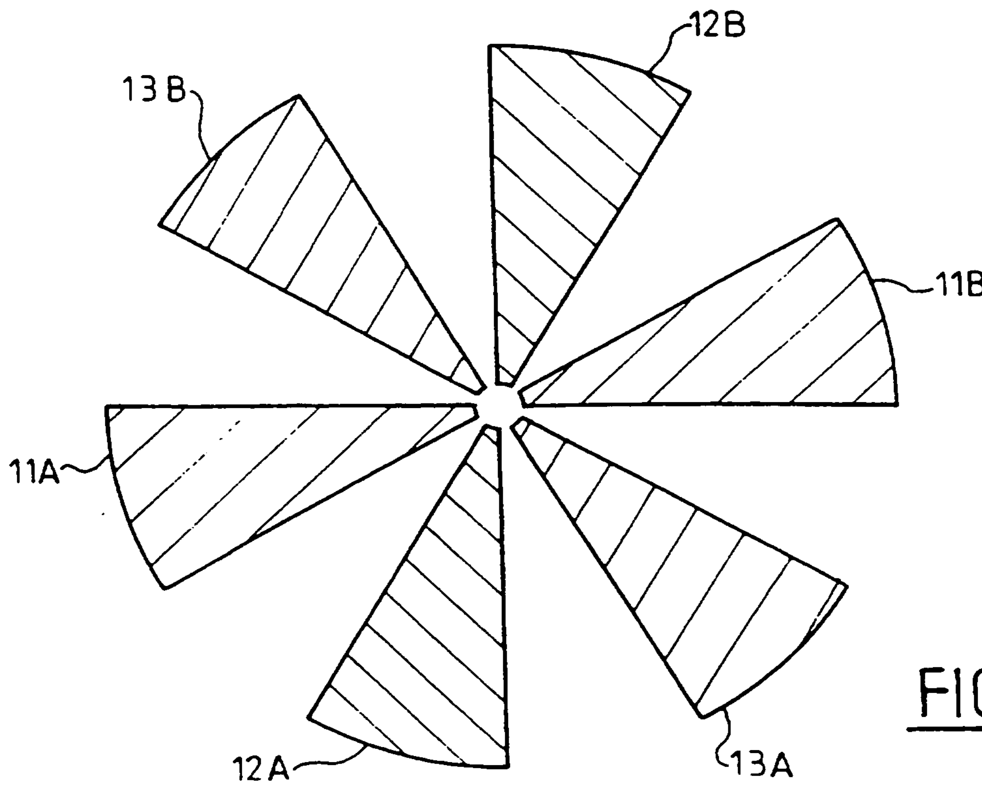

FIG. 3A

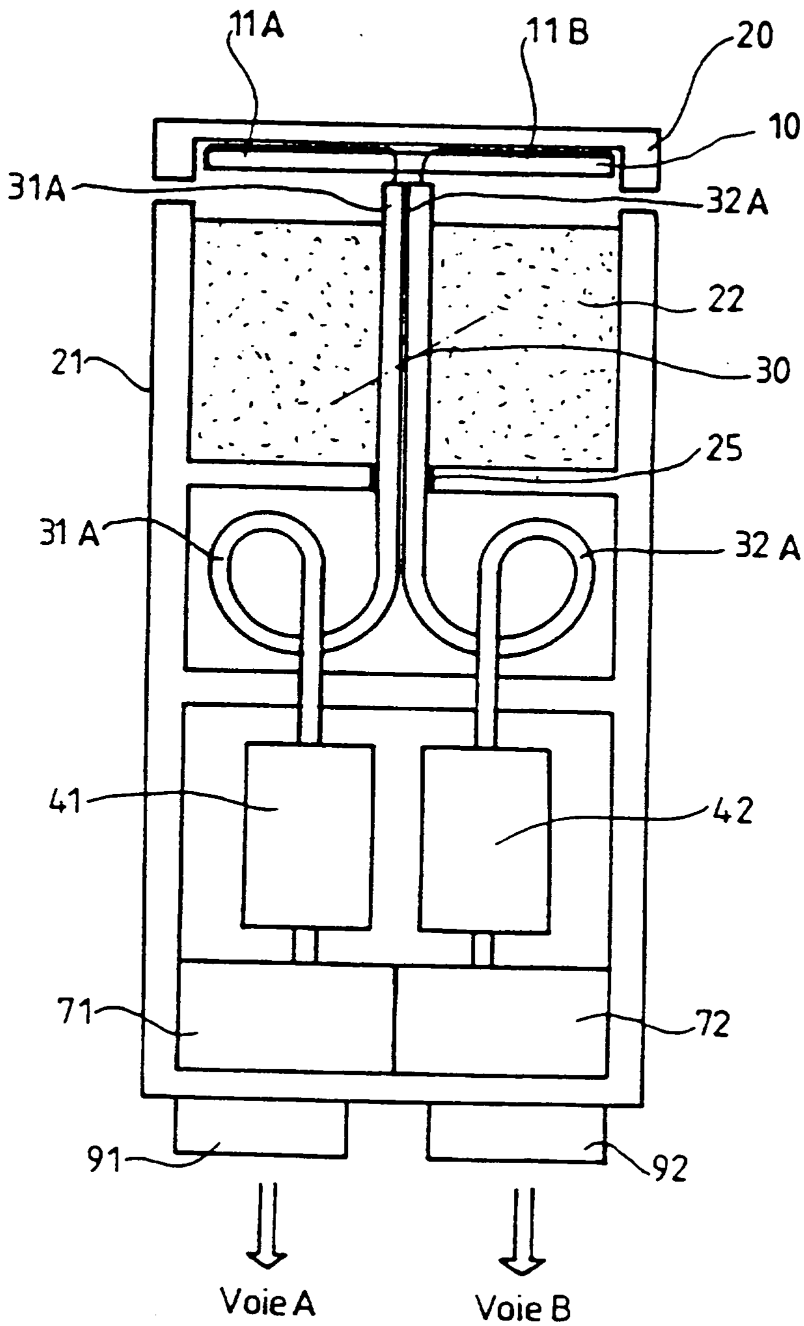
11A
11B
20
10
31A
32A
22
21
30
25
31 A
32 A
41
42
71
72
91
92
Voie A
Voie B

FIG.4

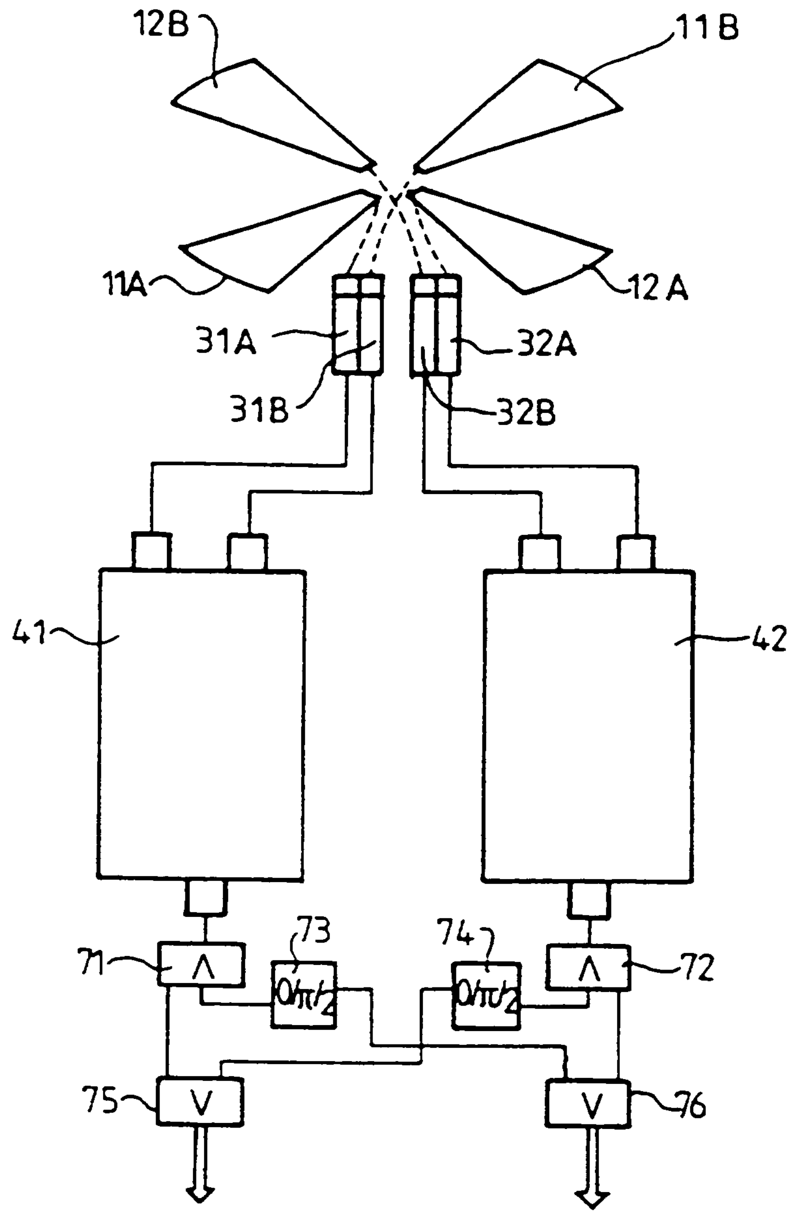
12B
11B
11A
12A
31A
32A
31B
32B
41
42
73
74
71
72
75
76

FIG.4A

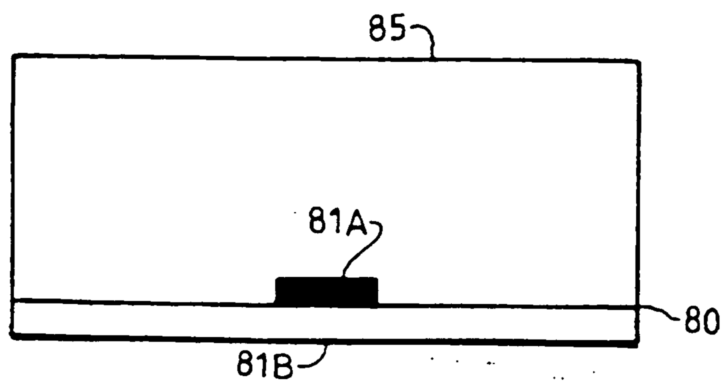
85
81A
80
81B

FIG.7

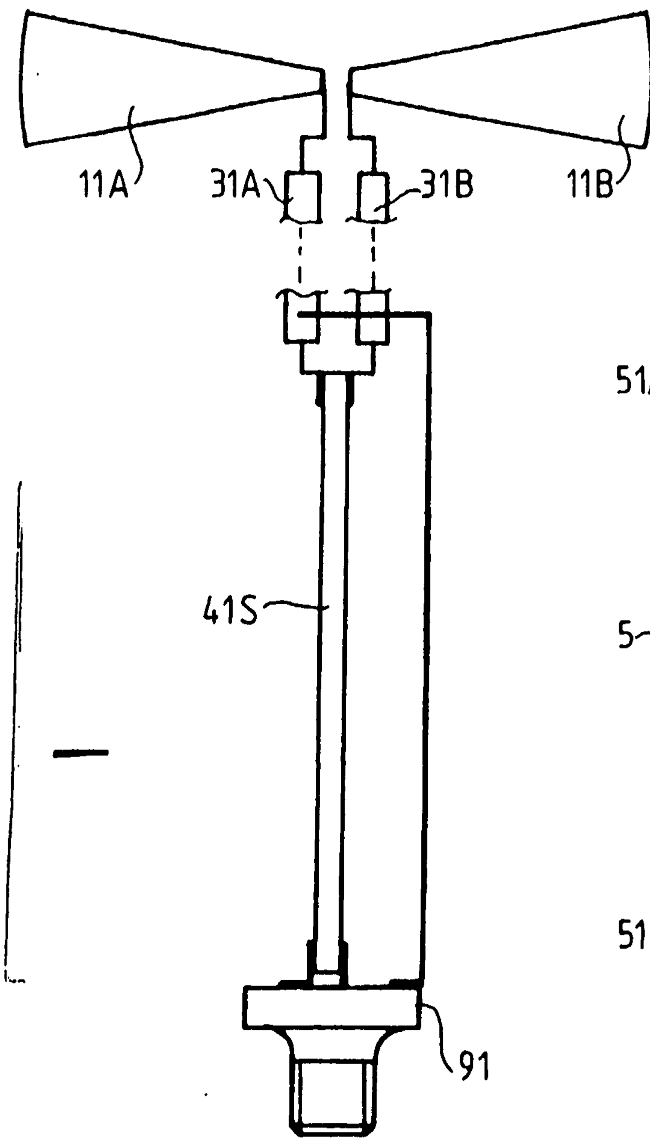

FIG.5A

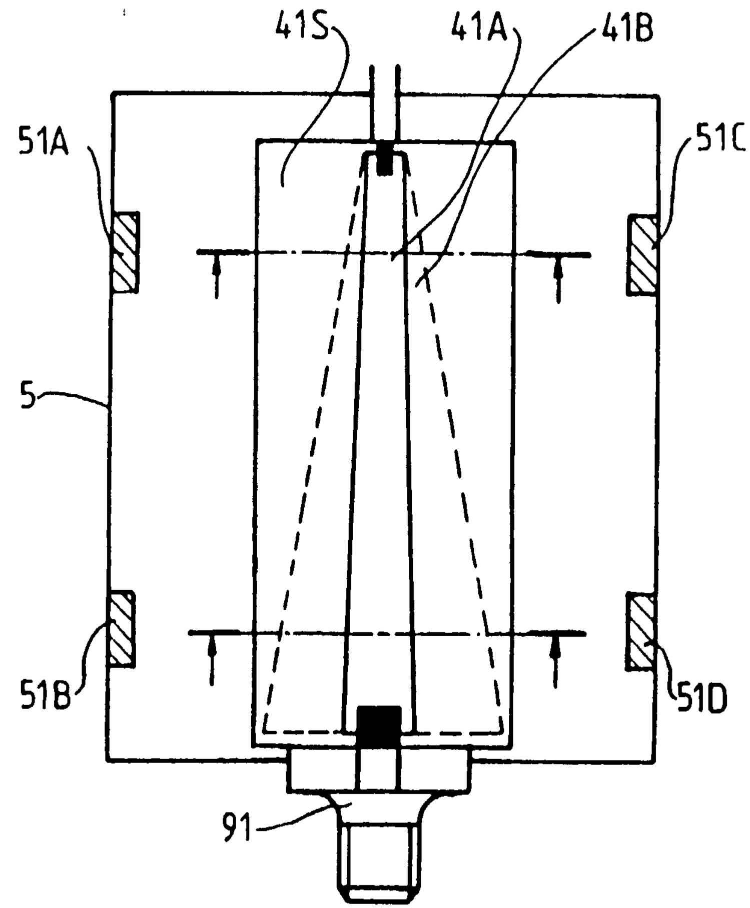

FIG.5B

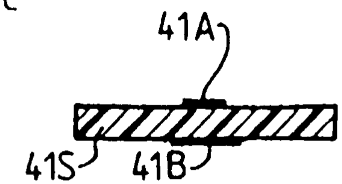

FIG.5C

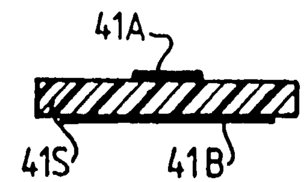

FIG.5D

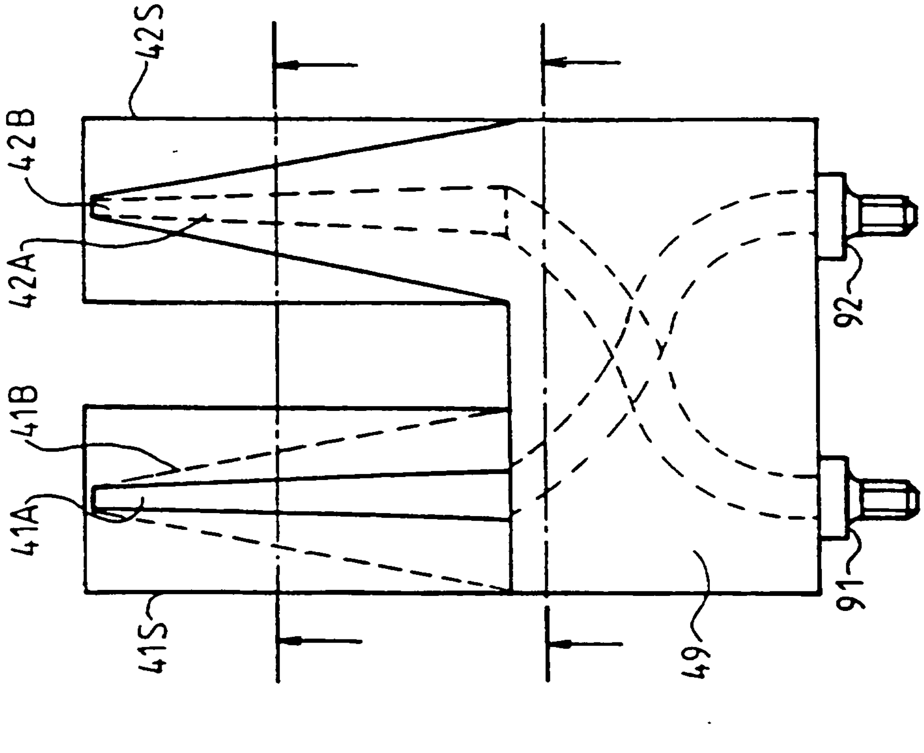

FIG.6A

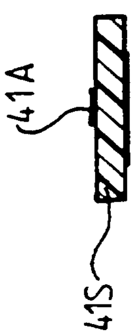

FIG.6B

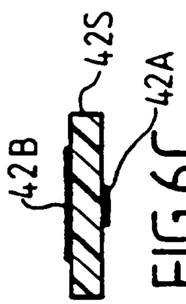

FIG.6C

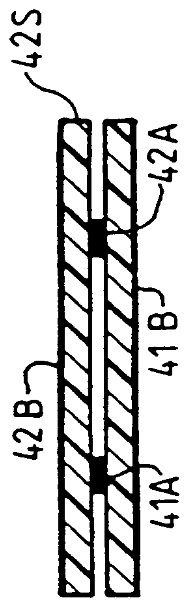

FIG.6D

Wide band radiating device capable of several polarizations

The present invention relates to antennas or radiating devices.

Even though numerous types of antenna exist, it still remains difficult to produce an antenna which is wide band, of small size, and capable of processing several polarizations with good radioelectric performance. This performance is measured in particular by the gain of the antenna, its radiation pattern, and the residual transmission level from one polarisation to another.

This problem has several other components such as the exact definition of the phase centre of such an antenna and the correct electric coupling of the antenna with the circuit working in conjunction with it.

Works have already proposed a radiating device called a "bow tie antenna" or "triangular dipole" which comprises a pair of thin conductive sectors, disposed head-to-tail on either side of an axis of symmetry, with a plane of symmetry passing through this axis:

- "Triangular dipole antennas", Antenna Engineering Handbook, R.C. JOHNSON & H. JASIK, Mac Graw Hill Book Company, page 25-12,
- "Experimentally Determined Radiation Characteristics of Conical and Triangular Antennas", G.H. BROWN & O.M. WOODWARD Jr, R.C.A. Review, Vol 3, N° 4, December 1952.

It is an object of the present invention to provide a wide band radiating device which is small and is capable of processing several polarizations with good radio-electric performance.

It is a further object of the present invention to provide an exactly defined phase centre of a wide band radiating device.

It is a still further object of the present invention to provide a wide band radiating device connected

to a circuit working in conjunction with it, and with correct electric coupling of the radiating device with the circuit.

Accordingly the present invention provides a radiating device, of the type comprising a substrate having a pair of thin conductive sectors disposed thereon, head-to-tail on either side of an axis of symmetry, with a plane of symmetry passing through said axis of symmetry, wherein said substrate also has at least one other pair of thin conductive sectors similar to the first-mentioned thin conductive sectors, each disposed with a further plane of symmetry passing through said axis of symmetry such that the planes of symmetry are substantially regularly distributed about said axis of symmetry.

In principle this allows the production of an antenna which is selective along several different directions (more precisely director planes) with respect to the axis of symmetry. However, in practice, most applications use only two directions which are perpendicular to each other: they correspond to two independent polarisation vectors; as will be seen below it is, in particular, possible to process either the horizontal polarisation and the vertical polarisation, or the right circular polarisation and the left circular polarisation.

Under these conditions, the proposed device comprises two pairs of conductive sectors whose planes of symmetry are perpendicular.

Even though it is possible to proceed otherwise, it is very advantageous that the conductive sectors should have substantially the same area as the insulating sectors defined between these conductive sectors. In this way a high performance radiating device is obtained without necessary recourse to active amplifying elements.

In a particular embodiment, each of the conductive sectors of the above-mentioned two pairs has an apex angle of approximately 45 degrees.

Most often, means are provided which prevent transmission of the radiation from one of the sides of the substrate. On this same side a link is provided, preferably by coaxial cables, to a matching assembly comprising two de-symmetrising baluns. The latter supply the vertical polarisation and the horizontal polarisation respectively as direct outputs. An interconnection assembly with a 0/90 degree phase shift allows the right circular and left circular polarizations to be obtained.

Other objects and advantages of the present invention will be more evident on examining the following detailed description taken together with the appended drawings, in which:

- Figure 1 is a general basic diagram of a known radiating device of the "bow tie" type;
- Figures 2, and 2A to 2I, show different basic embodiments of an antenna according to the invention;
- Figures 3 and 3A show two examples of pairs of conductive sectors;
- Figures 4 and 4A show the use of a radiating element in combination with an electrical coupling device;
- Figures 5A to 5D show an advantageous embodiment of such an electrical coupling;
- Figures 6A to 6D show another advantageous embodiment of such an electrical coupling; and
- Figure 7 shows a variant embodiment of the electrical output.

The drawings essentially have a definite character and define geometric characteristics. Consequently, they are to be considered as an integral part of the description and will be able not only to allow a better understanding thereof but will also contribute to the definition of the invention if necessary.

Figure 1 shows the basic diagram of a known antenna of the "bow tie" type. The latter is composed of two sectors 11A and 11B of generally triangular shape, placed

head-to-tail with their points facing each other. The two sectors are symmetrical with respect to a plane PS1 which is perpendicular to their own plane (assuming that these sectors are flat). In this instance, the sectors shown here are also symmetrical with respect to another plane PS2 perpendicular to the first one, with respect to the axis of symmetry AS of the two sectors 11A and 11B.

This antenna was the subject of theoretical proposals according to which the sectors 11A and 11B were in air.

In practice, the Applicant prefers to dispose these two sectors on a substrate 10 which is for example a glass-teflon material such as "DUROID", sold by the ROGERS Company of the United States.

As shown in Figure 2, there are disposed on the upper flat surface of a substrate 10 not only the two opposite sectors 11A and 11B, but also two other sectors 12A and 12B, having a plane of symmetry PS2 perpendicular to the plane of symmetry PS1 (Figure 1) of the sectors 11A and 11B.

Figures 2A to 2D show that the upper surface of the substrate 10 is not necessarily flat, but may correspond to any shape of revolution (Figures 2A and 2B), or to a prismatic shape having the same symmetries as the conductive sectors used (Figures 2C and 2D).

The peripheral edge of the sectors can be curvilinear, in principle convex. Similarly, Figures 2E to 2G show that the radial edges of the sectors can be curvilinear, having a variable or evolutive profile, in principle concave, in order to adjust the operating frequency band.

Furthermore, it is possible to etch one or more patterns inside the "bow tie" sector, for example with holes (Figure 2H) or with triangular cut-outs (Figure 2I). This also affects the frequency behaviour of the antenna.

Figure 3 shows an example of application of the invention which is currently considered as preferred. Only

two pairs of conductive sectors 11A ,12A, 11B, 12B are provided, separated by insulating sectors 11P, 12P, 11Q, 12Q.

According to another important characteristic of the invention, it is ensured that the total area of the insulating sectors and of the conductive sectors is substantially the same.

In an a priori unexpected manner, it has then appeared that:

- although dipole antennas of the bow tie type intrinsically have a relatively narrow bandwidth, it has appeared that the use of two dipoles such as defined above confers a considerably wider bandwidth on the dipoles. Typically, the bandwidth which could be hoped for from a bow tie dipole is improved in practice by a factor of 3 to 4.

- furthermore, insofar as two crossed radiating elements are used, that is to say at right angles with respect to each other, a very weak parasitic coupling has appeared between the signals at the terminals of the two pairs of radiating elements.

- finally, the pairs of radiating elements have a unique and well-defined phase centre, which confers important advantages on them for certain applications.

In another aspect, it appears that the operating frequency band which can thus be obtained would have required a dipole having an external diameter twice as big with the structure of the prior art.

In other words, a bandwidth which is three to four times wider is obtained with a structure whose transverse dimensions are half the size.

In view of the above, those skilled in the art will immediately understand that the new radiating device is extremely advantageous.

The cross structure in Figure 3 has specific advantages. But it is also possible to envisage the use of a structure having more than two pairs of dipoles, like for

example the structure having three pairs shown in Figure 3A.

The above described devices can be installed in modules, provided with their electrical coupling circuits. The mechanical diagram of such a module is shown in Figure 4 in simplified form, while an electrical circuit diagram is given in Figure 4A.

The two pairs of dipoles such as 11A and 11B, which can be placed under a radome 20, are placed at the top of a module 21, delimited by a metal body. The rear section of the substrate 10 faces an electromagnetic absorber 22, placed in the upper housing of the casing 21. Instead of an electromagnetic absorber, it is possible to use an electromagnetic reflector, or even a combination of the two, over different sections of the frequency band.

Four coaxial cables are provided (one for each conductive sector). The screens of the coaxial cables are connected to each other and to the metal casing 21. The cores of the coaxial cables are respectively connected to the live points of one of the conductive sectors. This defines coaxial cables 31A,31B, and 32A,32B for the conductive sectors 11A,11B and 12A,12B respectively.

Advantageously, in an intermediate housing of the casing 21, the coaxial cables form a loop, after which they join two de-symmetrising baluns 41 and 42.

The balun 41 receives the coaxial cables 31A and 31B, while the balun 42 receives the coaxial cables 32A and 32B.

By means of the loops which can be seen in Figure 4, it is ensured that the electrical lengths of the coaxial cables from the live point of the dipole in question to the balun are the same in order to align the propagation times of the signals. Furthermore, it is necessary to take account of the fact that the cables associated with the two opposite sectors 11A and 11B will have to be joined together again on the same balun 41. As represented by the axis line 30, this results in a rotation of the cables, with a

crossover, to allow the junction which has just been described. The intermediate loops allow for compensation in the possible differences in length due to this crossover.

The baluns 41 and 42 each have two coaxial inputs and each have one output, which is for example coaxial. A variant (Figure 7) consists of an output on a microstrip line which is applied to a printed circuit: on a substrate 80, the microstrip line 81A is opposite to an earth plane 81B, the complete assembly being under a metal screen 85.

In one embodiment, the patterns are known as "Minerva" or "Marchand" which are described for example in:

- Transmission Line Conversion Transformer", N. MARCHAND, Electronics, vol 17, p 142-145, December 1944,

- "100:1 Bandwidth Balun Transformer", J.W. DUNCAN & V.P. MINERVA, Proceedings of the I.R.E., pp 156-164, February 1960,

- "Design and performance of microstrip balun for Archimedes Spiral antennas", D.E. BAKER, J.R. NORTIER, C.A. VAN DER NEUT, Transaction of the SA Institute of electrical Engineers, December 1987.

In the case of four dipoles, it is firstly possible to use the outputs of the baluns 41 and 42, possibly through interface stages 71 and 72, in order to supply on connectors 91 and 92 channels A and B respectively which correspond to two crossed linear polarizations, such as the horizontal and vertical polarizations.

As a variant, as shown in Figure 4A, the two channels are applied to sub-dividers (reverse 3 dB couplers) 71 and 72. One of the outputs of the latter is applied to a 0/90 degree phase shifter, 73 and 74 respectively. The output of each phase shifter goes to a 3dB coupler, 75 and 76, situated on the other channel, and also receiving the other output of the coupler 71 or 72 of the same channel.

Those skilled in the art know that the coupling thus carried out allows the obtaining on output of signals having right circular polarisation and left circular

polarisation respectively.

Because of the small surface dimensions of the two pairs of basic dipoles, the module according to the invention can be produced with small lateral dimensions, the depth being a little greater, as can be seen in Figure 4.

This assembly is already satisfactory.

However, for certain applications it is desirable to have a large number of modules of this type in a volume which is as small as possible and for which the manufacturing is as simple as possible.

Two variant embodiments which are particularly advantageous in this respect will now be described.

Figures 5A to 5D relate to a variant embodiment in which interest is taken in only one of the channels, for example the horizontal polarisation defined by the sectors 11A and 11B.

The two coaxial cables 31A and 31B have cores which end respectively at two metallised surfaces of another substrate 41S. This substrate 41S can also be made of DUROID. On one side, the substrate 41S carries a relatively narrow metallisation 41A, which retains the same transverse dimension over its entire length (or widens very slightly), in order to end at the core of a coaxial connector 91 disposed at the other end.

The lower surface of the substrate 41S is provided with a metallisation 41B which, at the end near the core of the coaxial cable 31B, has practically the same width as the metallisation 41A. On the other hand, this metallisation 41B rapidly widens in order, on arrival, to be connected to earth at the much wider coaxial connector 91.

Those skilled in the art know that this produces the de-symmetrising according to the principle of a balun.

The advantage of the above embodiment is that it allows, with very few parts, the direct passage from the coaxial cables connecting the dipoles to the substrate 41S to a coaxial connector which directly supplies the output.

The assembly can be housed in a metal cavity 5, provided for example with mode absorbers 51A, 51B, 51C and 51D.

This is suitable for the case of transverse rectilinear polarizations.

Reference is now made to Figures 6A to 6D which show an even more advantageous variant in particular for circular polarisation.

In these Figures 6 are found two substrates 41S and 42S, for example made of DUROID. The latter are superimposed in the region of a zone 49 which is for example of generally rectangular shape.

Out of this zone, they have practically the structure already described with reference to Figure 5.

In brief, accepting that the substrate 41S is at a lower level than the substrate 42S:

- the substrate 41S carries on the bottom the greatly widening metallisation 41B which, and on the top the metallisation 41A which widens only slightly or not at all.

- the substrate 42S carries on the top the metallisation 42B which widens greatly, and on the bottom the slightly widening metallisation 42A.

Between the two substrates there is provided an insert of very small thickness made of a material similar to that of the substrate, such as DUROID.

In the vicinity of the superimposition section 49, the widened metallisations 41B and 42B spread completely in order to define earth planes situated above and below the sandwich thus constituted by the two substrates 41S and 42S and by the very thin intermediate layer (not shown).

The metallisations 41A and 42A can themselves be directly connected to the connectors 91 and 92 for the case in which it would be desired to make this assembly operate in rectilinear polarisation.

But the whole advantage of this assembly is in the case of circular polarisation:

- in this case it suffices to make the

metallisations 41A and 42A, at right angles to the superimposition section 49, follow paths which cross over with very adjacent portions.

This provides a coupling between the two channels, with the 0/90 degree phase shift function. Outputs with right and left circular polarisation are thus obtained directly on the connectors 91 and 92.

The variant of Figure 7 is of course directly applicable instead of the connectors 91 and 92.

It will be possible for other aspects of this embodiment to appear in our British Patent Application No. corresponding to French Patent Application No. 9015724.

The present invention is not limited to the described embodiments.

Firstly, as already indicated, the shape of the substrate 10 is not necessarily flat. Shapes which are approximately flat, or shapes of revolution, or prismatic shapes may be used. The radome 20 (Figure 4) may be shaped to constitute a lens or to have any other desired electromagnetic optical effect.

The proposed antenna has lambda/4 dimensions, instead of lambda/2 dimensions as for the prior art, lambda being the greatest wavelength, that is to say at the bottom end of the wide operating bandwidth. Furthermore, at the bottom of the band, it exhibits a progressive rise in gain with frequency. It can therefore be advantageous to use high impedance amplifiers in order to raise the gain at the bottom of the band.

More generally, the condition of equality of the conductive areas and non-conductive areas is not necessarily mandatory if amplifiers are added to the radiating elements which make an active antenna thereof.

When considering polarisation, it is appropriate to process the potential difference between two sectors or opposite dipoles. With the embodiments having more than two

dipoles it is possible to consider sums or differences, and more generally any linear combination of the potentials of the conductive sectors.

The processing of the collected signals can be carried out in parallel on different channels, or by multiplexing of a same processing channel.

Finally, the radiating elements according to the invention, with their coupler, appropriately screened, have not only small lateral dimensions but also a low lateral radiation considering their size and the frequencies in question. They therefore lend themselves particularly well to the construction of arrayed antennas.

The invention can be applied in numerous fields: telecommunications, particularly at microwave frequencies, and other microwave frequency applications including wide band measurements for example measurements on the radiation of other aerials.

CLAIMS

1. A radiating device, of the type comprising a substrate having a pair of thin conductive sectors disposed thereon, head-to-tail on either side of an axis of symmetry, with a plane of symmetry passing through said axis of symmetry, wherein said substrate also has at least one other pair of thin conductive sectors similar to the first-mentioned thin conductive sectors, each disposed with a further plane of symmetry passing through said axis of symmetry such that the planes of symmetry are substantially regularly distributed about said axis of symmetry.

2. A device according to Claim 1, wherein said thin conductive sectors have substantially the same area as the insulating sectors defined between said thin conductive sectors.

3. A device according to Claim 1 or 2, wherein said thin conductive sectors are disposed on the same surface of the substrate, and wherein the other surface of said substrate is provided with means preventing the transmission of the radiation.

4. A device according to Claim 3, wherein said means preventing the transmission of the radiation comprise radiation absorber means.

5. A device according to Claim 3 or 4, wherein said means preventing the transmission of the radiation comprise radiation reflecting means.

6. A device according to any one of Claims 1 to 5, wherein said conductive sectors are of generally isosceles triangular shape.

7. A device according to any one of Claims 1 to 6, wherein said thin conductive sectors have curvilinear radial edges.

8. A device according to any one of Claims 1 to 7, including means defining openings of chosen shape etched inside said thin conductive sectors.

9. A device according to any one of Claims 1 to 8, including another dielectric coating provided above said thin conductive sectors.

10. A device according to any one of Claims 1 to 9, wherein there are two pairs of conductive sectors whose angle at the apex is approximately 45 degrees, the respective planes of symmetry of the two pairs being perpendicular.

11. A device according to Claim 10, and further including four coaxial cables respectively connected on the one hand to said two pairs of conductive sectors, and on the other hand to a matching assembly comprising two de-symmetrising baluns.

12. A device according to Claim 11, wherein the outputs of said de-symmetrising baluns are interconnected with a 0/90 degree phase shift, in order to supply outputs with right circular polarisation and left circular polarisation.

13. A radiating device substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. A radiating device, of the type comprising an insulating substrate having n pairs of thin conductive sectors disposed thereon on either side of an axis of symmetry, each with a plane of symmetry passing through said axis of symmetry, such that the planes of symmetry are substantially regularly distributed about said axis of symmetry; wherein said thin conductive sectors have substantially the same area as the insulating sectors defined between said thin conductive sectors; and wherein there are n pairs of coaxial cables respectively connected in pairs on the one hand to said pairs of conductive sectors and on the other hand to a matching assembly comprising n de-symmetrising baluns.

2. A device according to Claim 1, wherein said thin conductive sectors are disposed on the same surface of the substrate, and wherein the other surface of said substrate is provided with means preventing the transmission of the radiation.

3. A device according to Claim 2, wherein said means preventing the transmission of the radiation comprise radiation absorber means.

4. A device according to Claim 2 or 3, wherein said means preventing the transmission of the radiation comprise radiation reflecting means.

5. A device according to any one of Claims 1 to 4, wherein said conductive sectors are of generally isosceles triangular shape.

6. A device according to any one of Claims 1 to 5, wherein said thin conductive sectors have curvilinear radial edges.

7. A device according to any one of Claims 1 to 6, including means defining openings of chosen shape etched inside said thin conductive sectors.

8. A device according to any one of Claims 1 to 7, including another dielectric coating provided above said thin conductive sectors.

9. A device according to any one of Claims 1 to 8, wherein the outputs of said de-symmetrising baluns are interconnected with a 0/90 degree phase shift, in order to supply outputs with right circular polarisation and left circular polarisation.

10. A radiating device according to claim 1 and substantially as hereinbefore described with reference to, and as illustrated in, Figures 2A to 2E and 3 and 3A of the accompanying drawings.

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Relevant Technical fields

(i) UK Cl (Edition K) H1Q (QBE, QKA, QDP)
H4J (JCD, JCE, JCF, JCX)

(ii) Int Cl (Edition 5) H01Q, H04R

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Databases (see over)

(i) UK Patent Office

(ii) On-line databases: WPI, Claims

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Documents considered relevant following a search in respect of claims 1-13

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2244381 (Philips)	1,3,5,7
X	GB 2165702 A (B. Gas) see Figure 3	1,6
X	GB 1023836 A (Kolbe et al)	1,6
X	WO 81/03398 A (Finken) see Figure 3	1,6
X	US 4922263 A (Dubort)	1,3,5
X	US 4038662 A (Turner)	1,6

SF2(p)